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CONE BEETLES: INJURY TO SUGAR PINE AND WESTERN YELLOW PINE.

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INTRODUCTION.

A class of damage which has been termed "blighted cones" occurs frequently in the seed crops of sugar pine throughout its range in California and Oregon and of western yellow pine in the Pacific coast and southern Rocky Mountain regions. This damage is distinguished by the dying of the immature cones soon after the starting of the second year's growth. The dead blighted cones, which are less than one-half the size of normal cones, are withered and faded to a reddish brown. The blighted sugar-pine cones fall to the ground during the first summer, whereas the blighted yellow-pine cones may adhere to the branches for several years.

INSECTS CAUSING DAMAGE.

The greater part of this damage[1] is caused by small scolytid beetles, which have been identified by Dr. A. D. Hopkins, of the Bureau of Entomology, as *Conophthorus* spp. The common name of "cone beetles" seems most appropriate for these insects, as their life history and the damage caused by them relate entirely to the cones of the host trees.

The adults are small, black, cylindrical beetles, from 3 to 4 mm. in length. The adult beetle bores a small tunnel through the axis of the cone, wherein the eggs are deposited. The larvæ, tiny white grubs from 3.5 to 4.5 mm. in length when full grown, feed upon the scales, seeds, and tissues of the withering cone.

The pupæ, which differ but little in size and color from the larvæ but possess the form of the adult, are formed within the same cone

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[1] The caterpillars of certain cone moths also kill immature second-year yellow-pine cones, in such a way that the damage resembles the work of the cone beetle, but this damage may be readily recognized by the character of the attack. In the areas observed by the writer the cone worms cause less than 10 per cent of the blighted cones.

Note.—This bulletin is the result of field observations made in Oregon and California. It is suitable for distribution on the Pacific coast.

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in which the larvæ develop. The brood of new adults is also formed in the same cone, and here the adults overwinter.

THE SUGAR-PINE CONE BEETLE.

(*Conophthorus lambertianae* Hopk.)

SEASONAL HISTORY.

Frequent observations in the field were made during the season of 1914 in the vicinity of Ashland and Colestin, Oreg., and near Hilt, Cal., at elevations ranging from 3,800 to 4,200 feet. The area near Hilt was located where the timber-felling operations of the California Fruit Growers' Supply Association were conducted, where seed-bearing sugar-pine trees were felled daily.

The brood of adults which overwinters in the cones infested during the previous spring and summer emerges the following spring. Records kept during the seasons of 1913 and 1914 from various lots of rearing material show that the maximum spring emergence occurs during May (see Table I, p. 3). Emergence from material collected in the fall and kept over winter in the laboratory has varied anywhere from April 19 to June 13. Emergence from material collected in the spring which had overwintered in the field and then was kept outside in muslin rearing sacks occurred from May 8 to 31. Frequent examination of cones in the field also showed that the emergence is occurring during this period and that it reaches its maximum between May 15 and June 1. The first attacks noted upon the 1913–14 cones occurred between May 25 and June 1. Continued fresh attacks were observed until about June 20. The following description covers all observations regarding the method of attack and subsequent habits of the beetle:

Sugar-pine cones at the beginning of the second-year growth are about 2 to 2½ inches long and are attached to the limb by a stalk from 2 to 3 inches long. The parent adult beetle attacks the cone by boring into the stalk of the cone. The position of this initial entrance varies greatly; usually it is just above the base of the cone, but it may occur anywhere from the base of the cone to an inch or more above. The wound made by the beetle soon produces a flow of resin which gradually accumulates on the surface in the form of a small pitch tube (Pl. II, fig. 1). After boring into the center of the stalk the beetle turns toward the cone and continues to extend its tunnel straight outward through the axis of the cone (Pl. II, fig. 2). After it advances well into the heart of the cone the tunnel becomes the egg gallery, and single eggs are deposited at intervals in notches excavated along the sides of the burrow. The entire length of the egg gallery is packed with sawdust. Sawdust is also packed around the eggs in the egg notches (Pl. II, fig. 2).

The rate at which the egg gallery is advanced by the adult has not been definitely determined, as it is impossible to determine the progress made by the adults without cutting the cone open, and when thus disturbed the adult at once ceases its work. However, it has been observed that the egg gallery has been extended entirely through the small cones within five to eight days after attack. For the same reason the period of incubation of the eggs within the cone has not been definitely determined. In cones cut open, eggs that had apparently just been deposited incubated in from two to four days.

One pair of parent beetles are found in each of these egg galleries. A series of specimens collected from individual cones was submitted to Dr. A. D. Hopkins, and from his determination of sex it was found that one male and one female beetle occupy each egg gallery. As a rule but one pair of beetles attack a single cone, but in some instances three pairs of beetles have been found advancing as many egg galleries in the same cone. The sex of the parent which makes the initial attack on the cone and begins the excavation of the egg gallery has not been determined.

The immediate effect of this attack on the cone is to check all further growth. Eventually the infested cone withers, then becomes dry and hard, but for a period of time it hangs on the tree in a semimoist and souring condition. It is during this period that the eggs of the beetle incubate and the young larvæ develop. The condition of the cone may be compared to that of the cambium of a pine which has been infested by Dendroctonus, and is in a fading or dying condition while the larvæ of the new broods of beetles are developing.

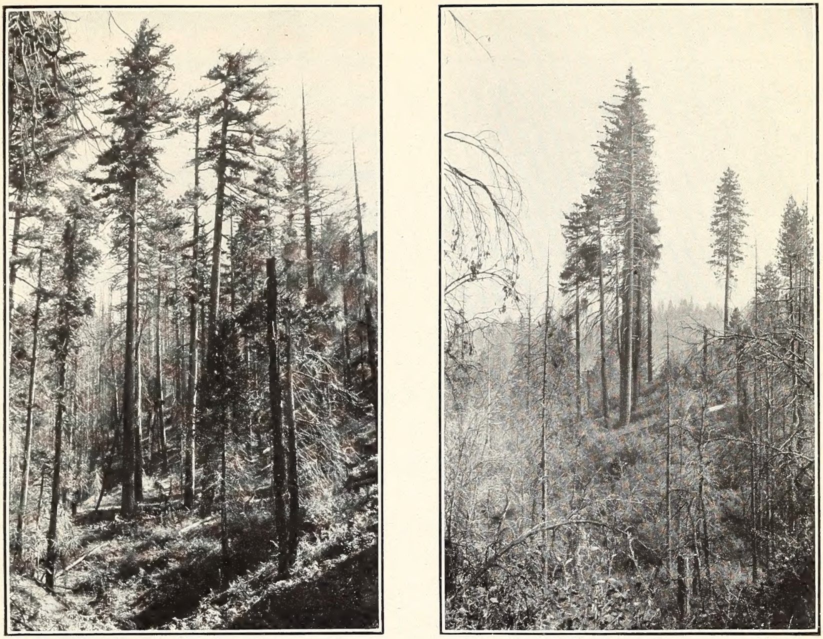
TABLE I.—*Emergence record of the sugar-pine cone beetle* (*Conophthorus lambertianae*) *in California and Oregon, 1913–14.*

Hopk. U. S. No.	Locality.	Date of collection.	Material.	Period of spring emergence of overwintered adults.	Remarks.
11471a	Kyburz, Cal.	Apr. 11, 1913	Overwintered adults in 1911–12 cones.	May 19–May 31, 1913; 43 adults.	Breeding cage kept outdoors.
11498	Pino Grande, Cal.	May 11, 1913	do	May 14, 1913; 12 adults.	Do.
10802	do	May 26, 1913	do	Emerging May 26, 1913.	A considerable percentage of unemerged adults still in cones.
10833a–2	Hilt, Cal	July 11, 1913	New adults in 1912–13 cones.	June 4, 1914; 6 adults.	Breeding cage kept in laboratory. Heavy emergence during Aug., 1913.
10833a–3	Ashland, Oreg.	Sept. 5, 1913	do	Apr. 19–June 4, 1914; 16 adults.	Breeding cage kept in laboratory.
10838a–2	Little Butte Creek, Oreg.	Aug. 23, 1913	do	Apr. 25–May 21, 1914.	Do.
10871a	Hilt, Cal	Nov. 13, 1913	do	June 2–June 13, 1914.	Do.
10871a–2	do	May 2, 1914	Overwintered adults in 1912–13 cones.	May 8–May 31, 1914.	Breeding cage kept outdoors.
10884a	Ashland, Oreg.	Feb. 14, 1914	do	May 19, 1914; 1 adult.	Breeding cage kept in laboratory.
10890a	Hilt, Cal	Mar. 13, 1914	do	Apr. 20–May 20, 1914; 10 adults.	Do.

The egg gallery is usually kept straight and close to the axis of the cone. During the early part of the season it has frequently been observed that in the small cones, from 2 to 4 inches long, the adults extend the egg gallery nearly to the outer end of the cone, depositing four or five eggs along its length, and then bore out through the scales and emerge. It has not been determined whether such emerging adults attack another cone or not, but it is reasonable to assume that this is the case. In the larger cones, from 6 to 8 inches long, which are attacked later in the season, from 15 to 30 eggs may be deposited; and as this probably represents the minimum number of eggs deposited by a pair of beetles, it is evident that very short cones do not afford sufficient length of egg gallery for the deposition of this number. Consequently a pair of parent adults may extend the egg gallery through several of the smaller cones before the egg-gallery capacity of the cone is exhausted.

As the attack continues through the latter part of June, the size of the attacked cones keeps increasing until the larger ones are from 6 to 8 inches long. The parent adults seldom emerge from these larger cones and later in the season will be found dead in the end of the egg gallery. By the 1st of July the new attack is complete. At this stage the infested cones are from 2 to 8 inches long, while the normal unattacked ones are from 10 to 18 inches long. The blighted cones are brown and stand out conspicuously on the trees. The seeds seldom form when the smaller cones are attacked, whereas the seeds of the larger cones that are attacked may reach two-thirds normal size and the outer shell may harden, but they never fill or mature.

Immediately after hatching the young larvæ begin to feed upon the scales and tissues of the now withering cone. They feed in such a manner as to leave no distinct lateral larval galleries. If the cones are opened during the larval period the small white grubs may be found in any part of the cone, the axis, scales, and often in the tender milky seeds (Pl. II, fig. 3). The development of the larvæ is very rapid. Pupæ may be found in the cones within four weeks after the first attack. By the last of June the cones which contain pupæ are dry, withered, and reddish brown in color. At about this stage the dry, withered stalks begin to break from the limbs and the blighted cones fall to the ground. All sugar-pine cones which are attacked fall from the trees before the close of the season and the broods complete their development in these fallen cones. The pupæ transform to new adults, which begin to appear by July 10, and this transformation continues throughout the summer, until by the middle of August the majority of the broods have reached the stage of new adults. Practically all of the infested cones have fallen by this time and the brood remains in these cones through



FIGS. 1 AND 2.—SUGAR-PINE SEED TREES ON BURNED AREA NEAR COLESTIN, OREG.

Photographs were made in July, 1914. The area was burned in 1910, destroying all young growth and much of the mature timber. Although the trees have put on several good crops since that date, there are scarcely any sugar-pine seedlings on the area. The seed crops have been repeatedly attacked by the sugar-pine cone beetle. (Original.)

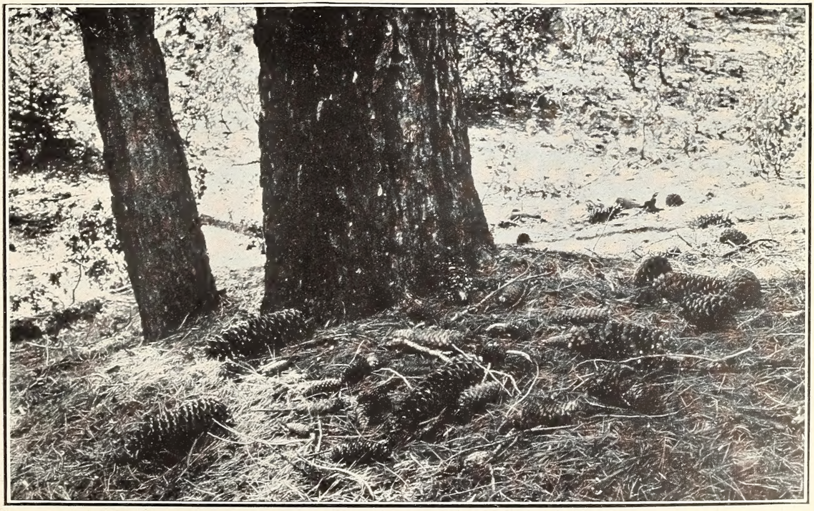


FIG. 3.—CONES ON GROUND UNDER SEED TREES.

The large opened cones are normal. The small cones have been killed by the cone beetle. (Original.)

WORK OF CONE BEETLES IN THE CONES OF SUGAR PINE.

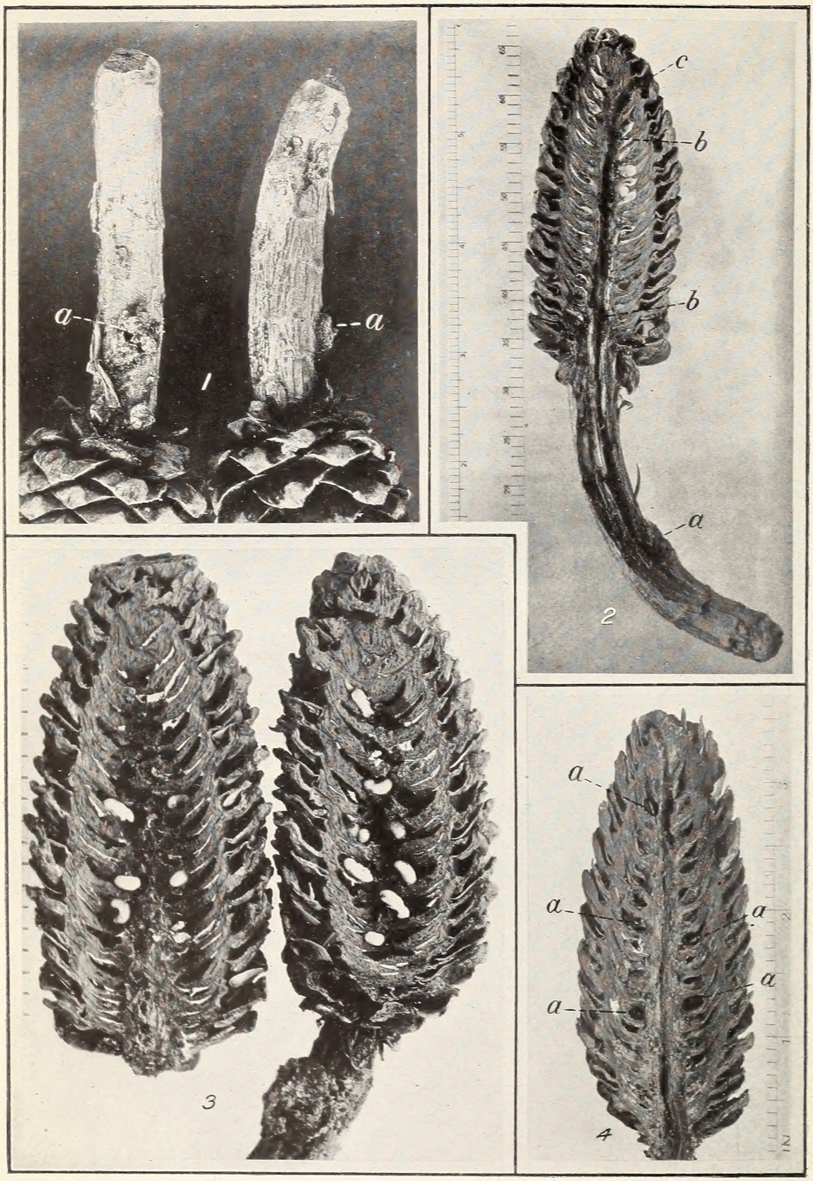


FIG. 1.—Showing stalks of beetle-killed sugar-pine cones after the cones have fallen from the tree: *a*, Entrance holes, showing small pitch tube made by beetle. FIG. 2.—A beetle-attacked sugar-pine cone opened to show tunnel and egg gallery of cone beetle: *a*, Entrace; *b*, egg gallery; *c*, extension of egg gallery to surface where adult emerges. FIG. 3.—Blighted sugar-pine cone opened to show developing broods of cone beetle. Larvæ and pupæ as found July 9, 1914. FIG. 4.—Blighted sugar-pine cone opened to show position of overwintering adults of cone beetle: *a*, Cone beetle adults. (Original.)

STAGES OF CONE BEETLES IN SUGAR-PINE CONES.

the remainder of the summer and the long overwintering period (Pl. II, fig. 4).

The new adults are not entirely dormant during this period, but feed to some extent on the dead tissue of the cone, as is apparent from the sawdust borings. The number of overwintering beetles which have been counted in a single cone varies from 1 to 36. The average, however, is from 6 to 10.

A considerable percentage of these blighted cones will always be found in which the beetles have made the attack and completed the egg gallery, but the larvæ have failed to develop. This failure of the broods is found more often in the very small and in the largest cones which have been attacked. The most successful attacks are found in the intermediate sized cones from 4 to 6 inches in length. Some of the larger cones appear to resist the beetles by drowning them out, as some trees are capable of resisting barkbeetles. In every attack, however, the cone is killed.

On certain areas great mortality to the new broods of the cone beetle, presumably through the work of an entomophagous fungus as yet not specifically determined, has been observed. In many of the cones the brood reaches the stage of full-grown larvæ, pupæ, or even new adults, and then dies. On an area near Sisson, Cal., in 1913, over 50 per cent of the cones contained these dead broods. On one area near Colestin, Oreg., in 1914, the brood developed in only 57 per cent of the attacked cones. The mortality of the developed broods amounted to 62 per cent, so the broods were finally successful in but 21.6 per cent of the cones attacked. The cause of this has not been determined and will require further study before conclusions can be drawn, although material illustrating the mortality of broods was sent in during the summer of 1914 and referred to the Bureau of Plant Industry. While it appeared to be an entomophagous fungus it has not yet been reported definitely. Few parasites of this cone beetle have been found.

All evidence points to the existence of but one generation of this species annually. The broods develop successfully only in the immature cones between 2½ and 8 inches in length. The period during which the cones may be found in this stage is so short that it allows for the development of one generation only. In August, 1913, an emergence of a considerable portion of the new generation of beetles was noted in northern California and southern Oregon. No subsequent attacks were observed on the nearly mature cones of the 1913–14 crop or upon the newly formed 1913–14 cones. No similar emergence was observed in 1912 or 1914, and the only explanation that can be given for the 1913 emergence was that it was abnormal, probably due to the unusual wet-weather conditions of that season.

The actual amount of loss to sugar-pine seed crops from this source is not easily estimated. Even though a great portion of the crop may be killed, the seriousness of the loss depends upon local factors, such as the desirability of reproduction by the natural reseeding of the infested areas or the demand for seed by local seed collectors. A number of observations have been made from 1912 to 1914 in the vicinity of Ashland, Grants Pass, and Colestin, Oreg., and in California on the Klamath, Shasta, Trinity, California, Plumas, Sierra, and Sequoia National Forests and in the Yosemite and General Grant National Parks. These observations indicate that the sugar-pine cone beetle is distributed throughout the range of the sugar pine, killing a varying percentage of the cone crops. In some places no appreciable damage is found, while in others over 90 per cent of the cones are killed by this insect. Apparently, through a period of years, local outbreaks may occur in well-defined centers of infestation anywhere throughout the range.

RELATION OF CONE-BEETLE DAMAGE TO THAT OF SQUIRRELS.

The beetle-killed cones fall during a part of the period in which the sugar-pine cones are cut by squirrels. As these rodents are the cause of the cutting and falling of a great part of the cone crop, it is only natural that some of the damage caused by the cone beetle should have been attributed to the squirrel. For this reason considerable attention was given to a study of the comparative damage during the season of 1914 from these two causes.

The first cutting of the cones by squirrels in 1914 was noted on June 25 near Butte Falls, Oreg., and later in July at Colestin, Oreg. Extensive cutting by the rodents did not begin until the middle of July, and they were active from then until the end of summer. Two species, the gray and the Douglas squirrel, were noted in connection with this damage. Important differences, however, readily distinguish this damage from that of the cone beetle.

1. Squirrels cut the stalk just above the cone and a part of the stalk is left on the limb. (Pl. V, fig. 1.) The wound where the stalk is cut may also show teeth marks of the rodent. Cones which fall from cone-beetle attack have the entire stalk attached to the cone. There are no teeth marks; a small resinous pitch tube is usually found on the stalk. (Pl. II, fig. 1.)

2. Cones cut by squirrels are usually eaten or cached by them. Beetle-killed cones are allowed to lie on the ground where they fall and are unmolested by the squirrels.

3. The majority of the sugar-pine cones cut by the squirrels are 10 inches or more in length and the seeds usually full size, although they may still be soft and milky. The majority of the beetle-killed cones are less than 8 inches; some of them not over 2½ inches. By the time the cones fall the seeds are blighted or hollow.

In order to obtain definite figures on the comparative damage from these two sources, two localities were selected in southern Oregon where the 1913–14 crop of cones was fairly good. A number of trees were selected which were so situated that the cones falling from them would not become confused with those falling from other trees. A record was made at intervals of the good cones and of those infested by the beetle or cut by squirrels. The results are shown in Table II.

TABLE II.—*Comparative loss to sugar-pine cone crop of 1914 caused by the cone beetle and squirrels.*

AREA NO. 1, NEAR COLESTIN, OREG. RECORD OF COUNT ON FIVE TREES.

Tree No.	Date.	Cones on trees.		Cones on ground.[1]	
		Good.	Beetle attacked.	Beetle killed.	Squirrel cut.
1	July 18	0	3	51	2
	July 29	0	0	54	2
	Aug. 8	0	0	54	2
	Aug. 21	0	0	54	2
2	July 18	1	5	17	1
	July 29	1	0	22	1
	Aug. 8	1	0	22	1
	Aug. 21	1	0	22	1
3	July 18	8	13	27	14
	July 29	0	2	38	22
	Aug. 8	0	2	38	22
	Aug. 21	0	0	40	22
4	July 18	16	10	31	0
	July 29	8	0	41	8
	Aug. 8	5	0	41	11
	Aug. 21	0	0	41	18
5	July 18	8	68	83	0
	July 29	6	33	115	2
	Aug. 8	4	4	147	4
	Aug. 21	1	0	151	7

AREA NO. 2, NEAR ASHLAND, OREG. RECORD OF COUNT ON THREE TREES.

1	Apr. 30	33	0	0	[2] 0
	Aug. 11	1	0	0	32
	Aug. 27	0	0	0	33
2	Apr. 30	14	0	0	[2] 0
	Aug. 11	10	0	2	1
	Aug. 27	3	0	2	8
3	Apr. 30	68	0	0	[2] 0
	Aug. 11	65	1	0	2
	Aug. 27	20	1	0	47

[1] The beetle-killed and squirrel-cut cones found under the trees on the first date were collected and put together in a pile. Those found on the following dates were collected and added to these; so that, in the above table, the number of cones on the ground at each date represents the total number found up to and including that date.

[2] Cones about one-fourth grown.

This table shows fairly well the period and rate of falling of the beetle-infested cones. It also shows the great variation in the damage.

On area 1 about 85 per cent of the cones were destroyed by the beetles, while on area 2 the attack of the cone beetle was so slight as to be almost negligible.

The damage by the cone beetle was therefore practically accomplished before that by squirrels was started. On area 1 this reduced the food supply of the squirrels, so that by the middle of July, when the serious cutting by the squirrels began, there was very little of the crop left for them.

Many large sugar pines standing on prominent ridges where they could easily seed several acres of the slopes below have failed to accomplish this result. One area which the author has studied closely is situated just above Colestin, Oreg., where a heavy fire in 1910 killed most of the timber on several sections, although a number of large seed-producing sugar-pine trees distributed over the area were but little injured. (Pl. I, figs. 1, 2.) However, in 1914 scarcely any sugar-pine seedlings could be found near these trees. Evidence that this area has been heavily infested by the cone beetle since the fire is plentiful, and in 1914 it destroyed 75 per cent of the crop, the squirrels completing the damage as shown in Table II under area 1.

Either the cone beetle or squirrels, but more probably a combination of the two, is responsible for the absence of satisfactory reproduction in situations where it is much needed.

THE WESTERN YELLOW-PINE CONE BEETLE.

(*Conophthorus ponderosae* Hopk.)

The general life cycle of the cone-beetle broods in yellow pine does not differ in any important respect from that in sugar pine. The first attack on second-year cones has been noted to occur from two to three weeks earlier. The period of maximum emergence occurred from May 1 to 15 on two small lots observed. Close observations on the period of attack and development in this host were made near Ashland at elevations from 1,800 to 2,200 feet. This is from 1,500 to 2,000 feet lower than the elevations at which similar observations were made on the beetles in the sugar pine. The comparative difference in seasonal history as shown by these observations will be found in Table I.

The first attack of adults in 1914 was noted on May 5, but the adults were only just starting to bore into the cone and no egg gallery had been commenced. From May 10 to June 1 continued fresh attack was noted, and the latest fresh attack occurred on June 10. By June 3 the earliest attacked cones contained a few pupæ and were beginning to turn brown and wither, so that they could easily be distinguished from the normal green, unattacked cones. By June 15 pupæ and a few new adults were found in the cones first attacked and very little fresh attack was noted. The gradual transformation of the brood progressed through the latter part of June and the first part of July, and by July 15 new adults were infesting practically all cones.

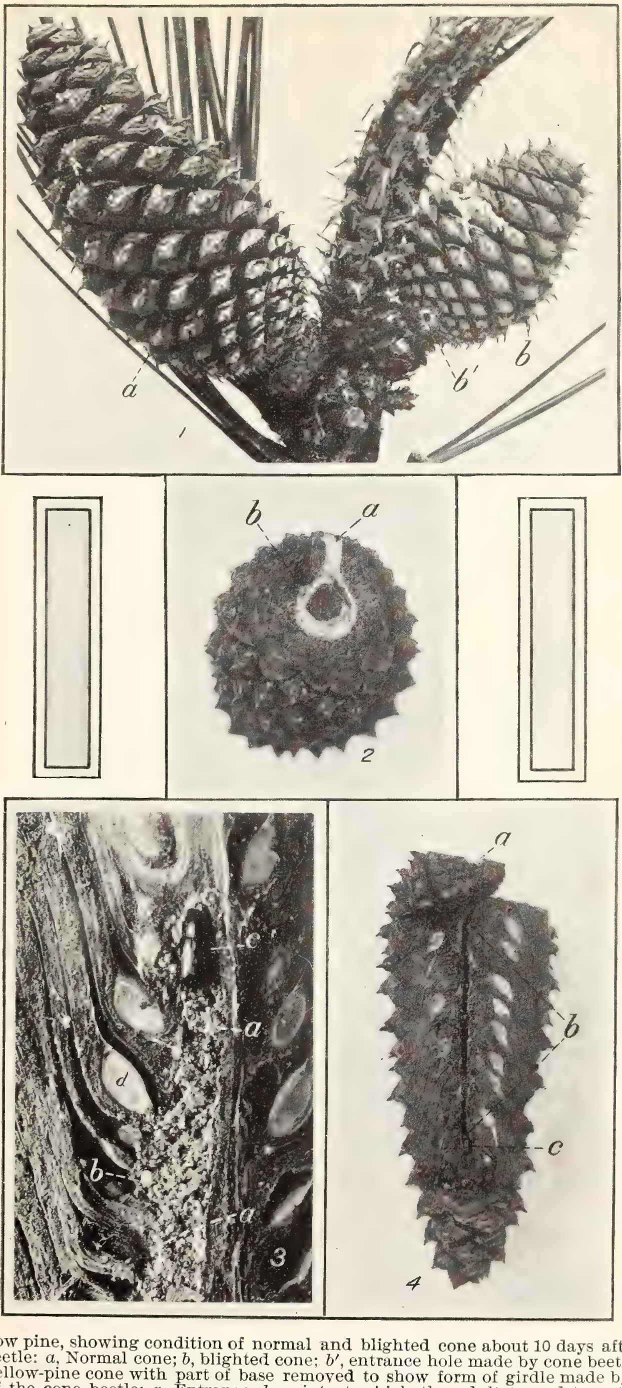
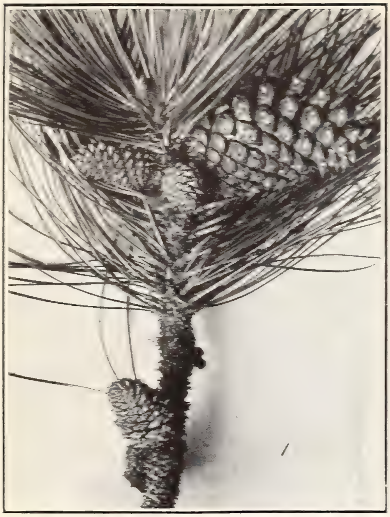
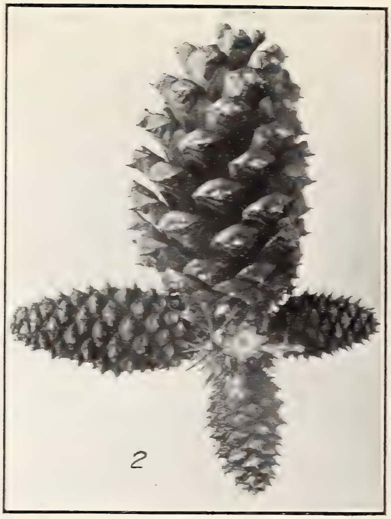
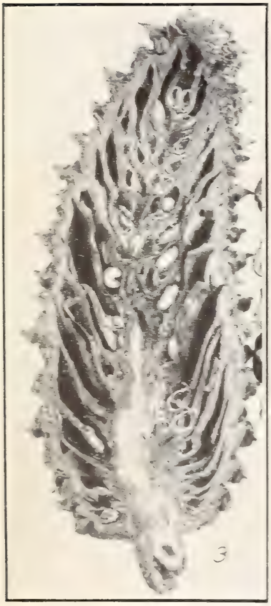


FIG. 1.—Yellow pine, showing condition of normal and blighted cone about 10 days after attack by the cone beetle: *a*, Normal cone; *b*, blighted cone; *b′*, entrance hole made by cone beetle. FIG. 2.—Blighted yellow-pine cone with part of base removed to show form of girdle made by the initial entrance of the cone beetle: *a*, Entrance; *b*, point at which the adult turned to extend the egg gallery into the axis of the cone. FIG. 3.—A portion of yellow-pine cone (near axis) opened to show egg gallery of the cone beetle, enlarged: *a*, Egg gallery, showing packed sawdust of beetle; *b*, egg; *c*, parent adult at terminus of egg gallery; *d*, immature seeds. FIG. 4.—Blighted yellow-pine cone with portion of base and scales removed to show the girdle made by the tunnel of the cone beetle and general form of the egg gallery: *a*, Entrance; *b*, egg gallery; *c*, parent adult. (Original.)

WORK OF CONE BEETLES IN CONES OF YELLOW PINE.







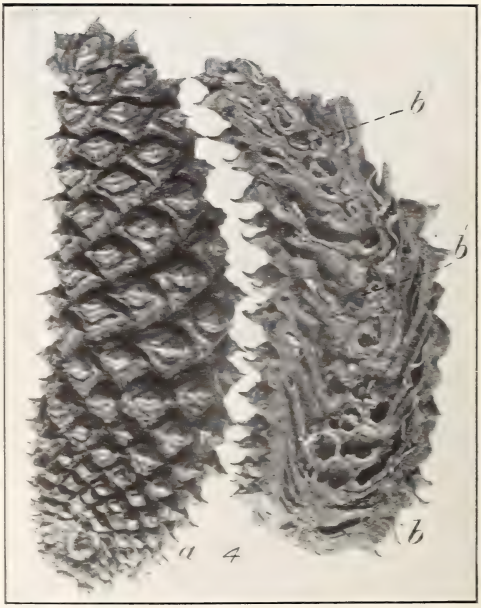


FIG. 1.—Blighted yellow-pine cones adhering to limb. This shows the position in which the majority of the yellow-pine cones are found. Near the terminal are shown three 1913-14 cones, two of them killed by the cone beetle. Farther back on the limb are the cones killed in 1912. FIG. 2.—A whorl of four yellow-pine cones, three of them killed by the cone beetle. The upper cone is normal. This shows the comparative size of the blighted and normal cones. FIG. 3.—A yellow-pine cone opened to show condition of developing brood of the cone beetle. This brood, on June 20, 1914, consisted of both larvæ and pupæ. (Slightly enlarged.) FIG. 4.—*a*, Blighted cone as it appears in overwintering condition; *b*, blighted cone opened to show damaged seeds and position of overwintering adults; *b'*, overwintering adults. (Original.)

WORK OF CONE BEETLES IN CONES OF YELLOW PINE.

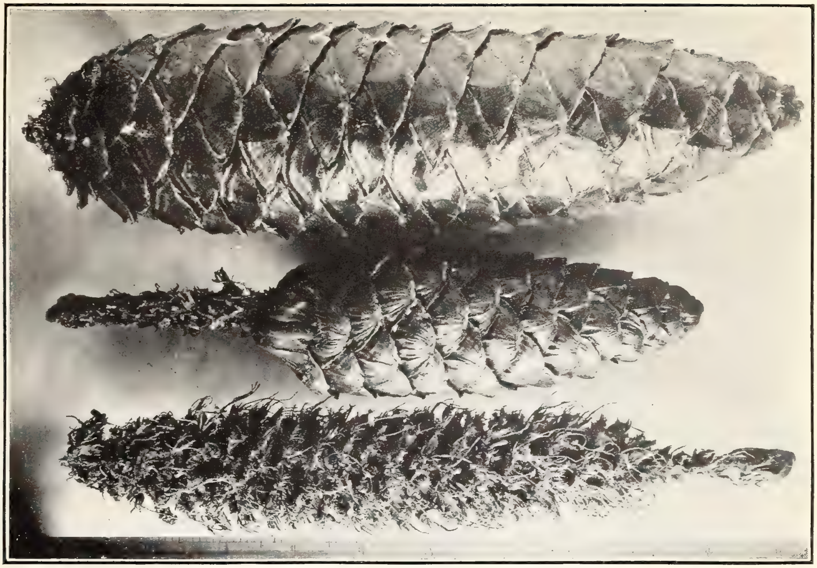


FIG. 1.—SUGAR-PINE CONES CUT BY SQUIRRELS.

The lower cone has been shucked and the seeds eaten. The cone in the center has been partly eaten. Note that the cones are cut at the base and do not have the stalk. Compare this with the blighted cones shown in Plate II, figure 1. (Original.)

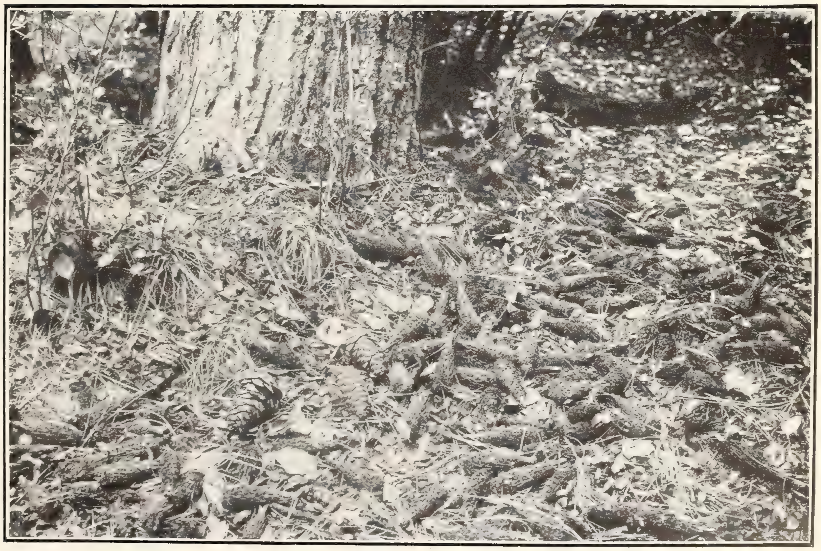


FIG. 2.—YELLOW-PINE CONES CUT AND EATEN BY SQUIRRELS. (ORIGINAL.)

SQUIRREL DAMAGE TO PINE CONES FOR COMPARISON WITH THAT BY BEETLES.

Yellow-pine cones are sessile; that is, instead of being attached, each to its individual stalk, they are set closely to the limbs. At the beginning of the second-year growth they are from 1 to 1½ inches long. Necessarily the initial point of attack must differ from that on sugar-pine cones. The adult enters the cone by penetrating the scales very close to the base of the cone. Sawdust borings may be seen on the surface of the scales and quite often a tiny pitch tube collects around the entrance of the burrow (Pl. III, fig. 1*b*′). The adult does not turn directly outward through the central axis of the cone, but bores completely around the axis, forming a short spiral tunnel (Pl. III, fig. 2). This spiral twist of the tunnel before the beginning of the egg gallery is not noticeable in sugar pine, but it is characteristic of attack in yellow pine. Its result is completely to cut off the nourishment and insure the deadening of the cone, which produces the condition necessary for the development of the larvæ. After completing this girdle at the base of the cone the adult extends the egg gallery out through the central axis (Pl. III, fig. 3). Oviposition (Pl. III, fig. 4), development of larvæ (Pl. IV, fig. 3), and transformation from pupæ to adults are in all important respects the same as with the sugar-pine cone beetle.

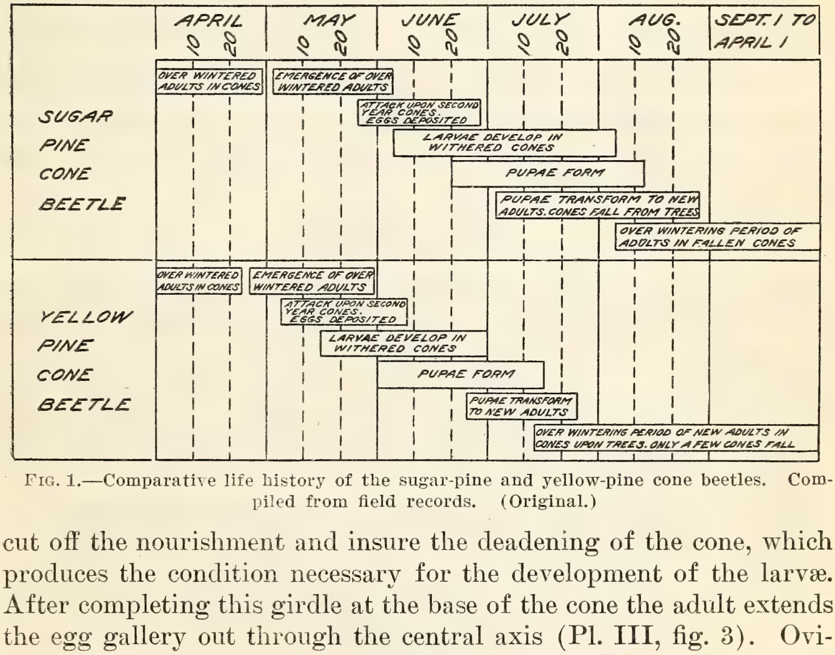


FIG. 1.—Comparative life history of the sugar-pine and yellow-pine cone beetles. Compiled from field records. (Original.)

In a few instances attacks have been observed on the small, first-year cones just after they "put on." This seems to be a rare habit, and has only been observed where there is a great scarcity of second-year cones. Eggs are not deposited and broods can not develop in these small cones.

Beetle-killed yellow-pine cones vary from 1 to 4 inches, the length, as in sugar-pine cones, depending largely on the stage of second-year growth when attack is made (Pl. IV, fig. 2). Yellow-pine cones, however, do not fall from the trees, and after they turn reddish brown in color they can be readily distinguished against the green foliage (Pl. IV, fig. 1). After the yellow-pine cones become dried they can not be broken readily from the limbs and quite often will be found still adhering many years after the beetles have abandoned them. The seeds may be formed, but they are invariably hollow in blighted cones (Pl. IV, fig. 4).

Occasionally a yellow-pine cone will be found that has been attacked by the beetle in which the new brood has failed to develop. The number of overwintering adults counted in the cones varied from 1 to 20, the average being from 5 to 8. The cone, however, is always killed and the damage is just as great.

The broods overwinter in the cones on the trees and emerge the following spring. (Pl. IV, fig. 4.) Adults do not appear to remain entirely dormant during this period, but feed to some extent on the dry scales and seeds. Mortality of the new broods, to any extent like that in the sugar pine, has not been observed. An examination of many infested cones of the 1913–14 crop shows that over 90 per cent of the new broods are alive.

AMOUNT OF DAMAGE.

The damage by the western yellow-pine cone beetle to yellow pine has never been noted to be as extensive as that of the species working in sugar pine. In heavy stands the loss to yellow pines is not so noticeable as it is on open isolated trees. Even in these isolated trees the amount of damage varies to a great extent on individual trees. Isolated trees at lower elevations, especially those bearing heavy cone crops, suffer most.

Two trees standing close together were selected and the cones counted as follows:

Tree No.	Green cones.	Beetle-killed cones.	Total.
1	515	448	963
2	700	65	765

The count was made August 5, 1914, at Ashland, Oreg. It shows how damage may vary with individual trees.

Estimates of the damage by this beetle necessarily depend upon the same factors as those pertaining to sugar pine. The damage, however, can not be confused with that of squirrels, as the beetle-killed yellow-pine cones adhere to the trees, while the squirrels invariably cut and either eat or cache the cones. (Pl. V, fig. 2.)

CONDITIONS REQUIRING CONTROL.

Since these insects are not a menace to growing timber, their control by direct expense is desirable only where it is found to be seriously interfering with the natural or artificial reproduction of the host tree. Under the conditions of the mature, well-stocked stands prevalent in the virgin forests of the West it is very doubtful whether the beetles ever interfere with the required natural reproduction to an extent sufficient to require artificial methods of control. Seldom is the entire crop killed and eventually through a period of years sufficient good seed is produced to replace the normal loss of trees from lightning, light fires, normal insect infestation, and overmaturity. However, conditions are entirely changed when the virgin forest has been destroyed by timber cutting, fire, or epidemic insect infestations. Yellow pine and sugar pine are rated as two of the most desirable timber species, and if the restocking of areas denuded of these species is to be accomplished by natural reproduction, full seed crops must be produced by the seed trees left on or near the areas. If the cone crops of such yellow and sugar-pine seed trees are repeatedly destroyed by the cone beetles, or if these infest them to such an extent that the destruction is completed by rodents, then the required seeding may be delayed until the ground is usurped by less valuable tree species. Under such conditions measures which will reduce the infestation of the beetle by direct expense may in the end effect a saving in the conservation of the forest. If burns or cut-over areas are restocked by artificial seeding the collection of sound, mature seed is necessary. Again, we may find that the cone beetles have so reduced the supply of cones on selected seed-collecting sites that seed can not be profitably collected. In the last case damage may be avoided by intelligent selection of noninfested seed-collecting areas. Or if the site is selected a year in advance, the infestation may be reduced and most of the seed crop saved by application of the remedy.

REMEDY.

From the discussion relating to the seasonal history of the insect it is obvious that from the last of August until the following May all the infestation within an area will consist of the broods of new adults which are overwintering within the blighted cones. It is evident that if fallen infested cones from the trees which seed in a burned or cut-over area can be raked up and burned between September 1 and May 1 a very appreciable reduction of the infestation and damage may result. In the case of sugar pine all infested cones will be found on the ground under the trees during this period and, when the conditions seem to warrant it, burning may be done without great expense. September, October, and November would be the more favorable months for the work, as winter snow and unfavorable conditions for burning will probably be found during the winter and spring.

Seed collectors in locating areas for collecting may estimate the amount of cone-beetle damage on the trees by July 15—in some situations a month sooner—as the blighted cones by that time begin to stand out conspicuously on the trees. From these estimates the collector may determine whether or not the seed crop of the current year is too badly damaged to be profitably collected.

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